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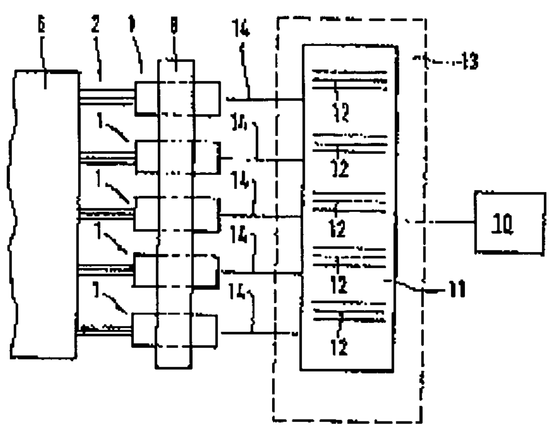
(12) **Patent Application:** (11) **CA 2334951**

(54) VOLTAGE MEASURING DEVICE

(54) DISPOSITIF DE MESURE DE TENSION

Representative Drawing:



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ABSTRACT:
The invention relates to a device for measuring the voltage at more than two identical voltage source units (6), comprising contacting means (2) for picking up the voltage and an evaluation unit (10) which is connected to the contacting means. At least several contacting means (2) are structurally combined in a contacting unit (1).

CLAIMS: Show all claims

*** Note: Data on abstracts and claims is shown in the official language in which it was submitted.

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(72) Inventors (Country): **SONNTAG, ANTON** (Germany (Federal Republic of))

SONNTAG, JOSEF (Germany (Federal Republic of))
EINHART, JOHANN (Germany (Federal Republic of))

(73) Owners (Country): BALLARD POWER SYSTEMS AG (Germany (Federal Republic of))

(71) Applicants (Country): XCELLSIS GMBH (Germany (Federal Republic of))

(74) Agent: KIRBY EADES GALE BAKER

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(72) EINHART, JOHANN, DE
(72) SONNTAG, ANTON, DE
(72) SONNTAG, JOSEF, DE
(71) XCELLSIS GMBH, DE

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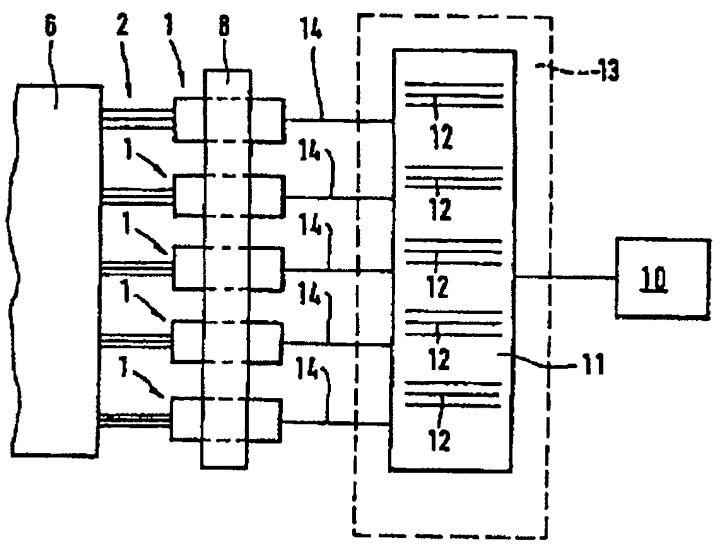
(54) **DISPOSITIF DE MESURE DE TENSION**
(54) **VOLTAGE MEASURING DEVICE**



(57) L'invention concerne un dispositif pour mesurer une tension au niveau de plus de deux unités sources de tension (6) identiques, comportant des moyens de contact (2) pour prélever la tension et une unité d'évaluation (10) raccordée aux moyens de contact. Au moins plusieurs moyens de contact (2) sont réunis dans une unité d'établissement de contact (1).

(57) The invention relates to a device for measuring the voltage at more than two identical voltage source units (6), comprising contacting means (2) for picking up the voltage and an evaluation unit (10) which is connected to the contacting means. At least several contacting means (2) are structurally combined in a contacting unit (1).

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New Patent Claim 1

1. Apparatus for voltage measurement on more than two identical voltage source units (6) having contact-making means (2) for voltage tapping, and having an evaluation unit (10) which is connected to the contact-making means, with at least a number of contact-making means (2) being physically combined in a contact-making unit (1), characterized in that a number of contact-making units (1) are arranged side by side, in the direction of their longitudinal axis (5), in a holder module (8), in that an intermediate unit (11) for addressing and/or pre-processing of measurement data is connected between the contact-making unit (1) and the evaluation unit (10), and in that each contact-making unit (1) is geometrically associated with a segment (12) of the intermediate unit (11).

2. Apparatus according to Claim 1, characterized in that segments (12) and contact-making units (1) are geometrically related to a standard grid size.

3. Apparatus according to Claim 1, characterized in that the contact-making unit (1) has a holder (3), electrically conductive contact-making means (2) and electrical connecting means (4) for an evaluation unit (10) or for an intermediate unit

(11) which is connected between the evaluation unit (10) and the contact-making unit (1).

4. Apparatus according to Claim 1, characterized in that the contact-making means (2) of the contact-making unit (1) have electrical spring contacts which can be detached from voltage source units (6) with which contact is to be made.

5. Apparatus according to Claim 1, characterized in that the contact-making unit (1) is arranged in the holder module (8) such that it can be moved in the direction of its longitudinal axis (5).

6. Apparatus according to Claim 1, characterized in that the contact-making unit (1) projects at right angles into a guide rail (9) of the holder module (8) in such a way that the contact-making unit (1) can be moved along the guide rail (9), parallel to the longitudinal extent of the housing (13), or parallel to a stacking direction of the voltage source units (6).

7. Apparatus according to Claim 1, characterized in that the evaluation unit (10) is a central controller.

8. Apparatus according to Claim 1, characterized

in that the evaluation unit (10) has a unit for addressing and/or pre-processing of measurement data.

9. Apparatus according to Claim 1,
characterized
in that the contact-making unit (1) is in each case at least indirectly electrically connected by means of a ribbon cable (14) to the evaluation unit (10) or to the intermediate unit (11).

10. Apparatus according to Claim 1,
characterized
in that, in addition to segments (12), the intermediate unit (11) has a base unit (15) which has at least one data bus interface and/or a microcontroller card.

11. Apparatus according to Claim 1,
characterized
in that the segment (12) has multiplexer units and electrical connection means (4.1) allocated to the segment (12), to which connection means (4.1) one or more contact-making units (1) can be connected.

12. Apparatus according to Claim 1,
characterized
in that contact-making units (1) and/or electrical connection means (4.1) and/or regions of the multiplexer units (M) and/or segments (12) with multiplexer units (M) and connection means (4.1) are arranged at equal intervals along the longitudinal axis of the intermediate unit (11).

13. Apparatus according to Claim 11 or 12, characterized in that the longitudinal extent at least of segments (12), connection means (4.1) and contact-making units (1) is staggered along the longitudinal axis of the intermediate unit (11), in which case the longitudinal extent of the contact-making units (1) is a first length (L1), the longitudinal extent of the regions of multiplexer units (M) is a second length (LM), the longitudinal extent of the connection means (4.1) is a third length (L4), and the longitudinal extent of the segments (12) is a fourth length (L12), where L1>L12>L4>LM.

14. Apparatus according to Claim 11, 12 or 13 characterized in that the longitudinal extent at least of segments (12), connection means (4.1) and contact-making units (1) is staggered along the longitudinal axis of the intermediate unit (11) and is arranged offset with respect to the stacking direction of the voltage source units (6) so that the function of segments (12), connection means (4.1) and contact making units (1) is maintained when shortened to a present stack length of the voltage source units (6).

15. Apparatus according to Claim 1, characterized in that the holder module (8) can be attached to the housing (13).

16. Apparatus according to Claim 1, characterized in that the holder module (8) can be attached to the voltage source units (6).

17. Apparatus according to Claim 1, characterized in that attachment means of the intermediate unit (11) in the housing (13) are provided with means to compensate for changes in the length of the intermediate unit (11) and/or of the housing (13).

18. Apparatus according to Claim 1, characterized in that the contact-making unit (1) is connected to a discharge module, by means of which at least one voltage source unit (6) can be discharged.

19. Apparatus according to Claim 18, characterized in that the discharge module is provided with means for connection of an electronic data processing device.

20. Apparatus according to Claim 1, characterized in that the voltage source unit (6) is a fuel cell.

28391/WO/1

Apparatus for voltage measurement

The invention relates to an apparatus for voltage measurement on more than two identical voltage source units, according to the precharacterizing clause of the independent claim.

A voltage source unit of this generic type is formed, for example, from one, or preferably from a number of elementary battery cells or else from one, or preferably from a number, of elementary fuel cells.

One preferred field of application for such an arrangement for voltage measurement is fuel cell systems, in particular with H_2/O_2 fuel cells, which normally supply a cell voltage of approximately 0.5 V to 1.0 V. In order to achieve higher voltages, and thus higher power levels, individual fuel cells are connected in series to form a stack. When the fuel cells are being operated, it is necessary to ensure that the fuel cells operate effectively and that the power supplied from the fuel cell stack does not force individual fuel cells to assume impermissible or dangerous operating states with a negative cell voltage, but that the cell voltages are maintained within a certain bandwidth, depending on the load state. Furthermore, it is desirable to be able to detect defects, which can lead to failure of a fuel cell, at the H_2/O_2 separation unit.

DE-A1 43 38 178 discloses an arrangement in which fuel cell stacks are connected in series in at least two parallel connected rows each having the same number of stacks in the rows, and in which the rows are split into arms of a bridge circuit and are connected to at

least one evaluation arrangement which evaluates the voltage tapped off between the arms, or the current tapped off.

DE-C2 195 23 260 discloses a method for monitoring more than two identical voltage source units, in which contact tips are pressed against carbon contacts of fuel cell stacks which are combined to form blocks. However, the contact with the stacks is susceptible to vibration and, in particular is not suitable for use in a motor vehicle since, essentially only a stationary measurement is possible, and not continuous measurement in operational conditions.

The object of the invention is to specify an arrangement for voltage measurement on more than two identical voltage source units, which is simple to fit, allows permanent voltage monitoring and flexible handling as well as simple and cost-effective matching to fuel cell stacks of different size, and which is suitable in particular for use in mobile systems such as motor vehicles, as well as in stationary systems.

The object is achieved by the features of the independent claim. Further-reaching and advantageous refinements can be found in the further claims and in the description.

The apparatus according to the invention for voltage measurement on more than two identical voltage source units is provided with contact-making means for voltage tapping and with an evaluation unit which is connected to the contact-making means, in which case at least a number of contact-making means are physically combined in a contact-making unit.

The contact-making unit preferably has a holder, electrically conductive contact-making means and

electrical connecting means, in particular pin-type plug connectors, for an evaluation unit or for an intermediate unit which is connected between the evaluation unit and the contact-making unit.

It is particularly preferable for the contact-making means of the contact-making unit to have electrical spring contacts which can be detached from voltage source units with which contact is to be made.

In one advantageous arrangement the contact-making unit is in the form of a flat plate on which spring contacts are arranged approximately parallel to one another and projecting essentially at right angles from the longitudinal axis of the plate, in which case the spring contacts are each firmly electrically conductively connected at one end to the respective associated electrical contact surface, and their free end can move at least in the direction of the longitudinal axis. In this case, it is particularly expedient for the contact-making means to have a corrosion-resistant metallic surface, at least in some places. It is advantageous for retaining surfaces for contact-making means to be provided for voltage tapping on the surface of the voltage source units.

In one preferred arrangement, the contact-making unit is arranged in a holder module such that it can be moved in the direction of its longitudinal axis. It is advantageous to arrange a number of contact-making units side by side in the direction of their longitudinal axis in a holder module, so that the contact-making means point outwards like a comb.

The contact-making unit expediently projects at right angles into a guide rail of a holder module in such a way that the contact-making unit can be moved along the guide rail parallel to the longitudinal extent of a

housing, or parallel to a stacking direction of the voltage source units.

The evaluation unit is advantageously arranged in a housing. It is advantageous for the evaluation unit to be a central controller. A further advantageous refinement is for the evaluation unit to have a unit for addressing and/or pre-processing of measurement data. It is particularly advantageous for an intermediate unit for addressing and/or pre-processing of measurement data to be connected between the contact-making unit and the evaluation unit.

One particularly expedient refinement is for the contact-making unit in each case to be at least indirectly electrically connected by means of a ribbon cable to the evaluation unit or to an intermediate unit which is connected between the contact-making unit and the evaluation unit.

In one particularly preferred refinement, each contact-making unit is allocated a segment of an intermediate unit. It is advantageous if, in addition to segments, the intermediate unit has a base unit which has at least one data bus interface and/or a microcontroller card. It is advantageous for the intermediate unit to have at least connecting means for a CAN bus.

The segment preferably has multiplexer units and electrical connection means allocated to the segment, to which connection means one or more contact-making units can be connected.

In one particularly preferred development, contact-making units are arranged at equal intervals along the longitudinal axis of the intermediate unit. Electrical connection means are preferably arranged at equal intervals along the longitudinal axis of the

intermediate unit. Furthermore, regions of multiplexer units are preferably arranged at equal intervals along the longitudinal axis of the intermediate unit. Furthermore, segments with multiplexer units and connection means are preferably arranged at equal intervals along the longitudinal axis of the intermediate unit.

It is particularly preferable for the longitudinal extent at least of segments, connection means and contact-making units to be staggered along the longitudinal axis of the intermediate unit, in which case the longitudinal extent of the contact-making units is a first length L1, the longitudinal extent of the regions of multiplexer units M is a second length LM, the longitudinal extent of the connection means is a third length L4, and the longitudinal extent of the segments is a fourth length L12, where L1>L12>L4>LM.

Advantageously, the longitudinal extent at least of segments, connection means and contact-making units is staggered along the longitudinal axis of the intermediate unit and is arranged offset with respect to the stacking direction of the voltage source units so that the function of segments, connection means and contact making units is maintained when shortened to a present stack length of the voltage source units.

In one advantageous embodiment, the holder module can be attached to the housing. In a further advantageous embodiment, the holder module can be attached to voltage source units.

It is expedient to provide attachment means of the intermediate unit in the housing with means to compensate for changes in the length of the intermediate unit and/or of the housing.

In one particularly advantageous refinement of the invention, the contact-making unit is connected to a discharge module, which forms a low impedance bridge for at least one voltage source unit. It is thus possible to deliberately discharge units in the voltage source units individually, or to discharge a number of such units in a stack, and to remove them safely, for example for maintenance purposes. It is particularly advantageous for the discharge module to be provided with means for connection of an electronic data processing device and, in particular, to be controllable by software.

The voltage source unit is preferably a fuel cell.

It is particularly preferable for retaining surfaces for the contact-making means to be provided for voltage tapping on the surface of the fuel cell. This makes contact with spring contacts particularly robust and reliable, in particular with respect to shock and/or vibration.

The modular construction of the apparatus according to the invention allows the apparatus to be used highly flexibly and cost-effectively.

The features, to the extent that they are important to the invention, are explained comprehensively in the following text and are described in more detail with reference to figures, in which:

Figure 1 shows an outline sketch of a contact-making unit according to the invention,

Figure 2 shows a section through a contact region between voltage source units and contact-making means,

Figure 3 shows a contact-making unit in a holding module,

Figure 4 shows an outline sketch of an advantageous arrangement of the contact-making unit,

Figure 5 shows an outline sketch of one advantageous arrangement of the voltage measurement apparatus,

Figure 6 shows details of a preferred intermediate unit,

Figure 7 shows a preferred geometric configuration of the individual modules, and

Figure 8 shows details of a preferred arrangement of contact-making means.

The invention is explained in the following text with reference to fuel cell systems. However, it is self-evident that the use of the described apparatus according to the invention is not limited to fuel cell systems, but can also be used for other voltage source systems in mobile and stationary systems, such as multicell battery systems and/or rechargeable batteries and/or capacitor banks and/or multi-channel systems. Use in vehicles or other transportation means is particularly advantageous.

A fuel cell stack which is intended to provide electrical power in particular for motor vehicle traction is formed from a large number of series-connected fuel cells, for example 100 to 200 individual cells.

By virtue of its modular construction, the apparatus according to the invention allows the voltage measurement apparatus to be matched very easily and cost-effectively to different fuel cell numbers and, by virtue of the particular mechanical flexibility of the contact-making means, even to fuel cells with different widths, without having to design and match a new voltage measurement apparatus for each stack version.

A contact-making unit 1 as claimed is shown in Figure 1. According to the invention, the contact-making means 2 are physically combined in the contact-making unit 1. A contact-making unit 1 preferably comprises contact-making means 2, a holder 3, in particular a board with conductor tracks, and a connection means 4, on which the measured values can be tapped off. The connection means 4 is preferably a plug to which a connecting cable can be connected and which is electrically connected to the contact-making means 2.

One preferred contact-making unit 1 is a microcontroller card, preferably having a large number of electrical cables as contact-making means 2, which electrical cables are fitted to the contact-making unit 1 and are intended for tapping voltages on the voltage source units 6.

One particularly preferred contact-making unit 1 has a number of spring contacts as contact-making means 2, which are combined on the contact-making unit. It is advantageous to use a number of contact-making units 1, arranged in series, for voltage measurement.

The spring contacts have the advantage that, firstly, reliable electric contact can be made with the fuel cells in a fuel cell stack and, secondly the contacts can be detached from the fuel cell stack. During manufacture of the spring contacts, it is possible, using simple means, in particular by deliberate bending and bending over of the spring wire or of the spring leaf to allow the spring contacts to have a defined contact pressure, so that the contacts allow reliable electrical contact with the fuel cell, even in the event of the arrangement being subjected to vibration. This is particularly advantageous for use of the voltage measurement apparatus in a vehicle, thus

allowing, in particular, permanent monitoring of fuel cells even during operation. The preferred spring contacts can be manufactured cost-effectively, in particular in large quantities. The contact resistance between the spring contacts and the fuel cell is essentially governed by the size of the contact area and by the contact force. The spring force is achieved by the spring wires being bent over through a defined distance during manufacture. When the apparatus according to the invention is being fitted to a fuel cell stack, the desired contact force of the spring contacts can be adjusted.

A further advantage is that the interface complexity between the measurement electronics and the voltage tap is low due to the contact-making means 2, since there is no need for long measurement cables. This also reduces any susceptibility to interference from electromagnetic radiation for the cell voltage measurement variables, so that the electromagnetic compatibility of the apparatus is highly suitable for use in a motor vehicle, or other usage locations which are subject to electromagnetic radiation. Our own EMC measurements have shown that the apparatus used complies with the present-day requirements for electromagnetic compatibility.

Expediently, at least in the region where contact is intended to be made, each spring contact is provided with a corrosion-resistant metallic coating. The spring contact is preferably gold-plated. In this case, it is a good idea not to apply the corrosion-resistant coating until after the spring contacts have been bent, in order to avoid the bending stress producing any microscopic cracks in the coating.

The spring contacts are preferably arranged on the holder 3 such that they project from the holder 3 like

a comb. In this case, the spring contacts are arranged at right angles to a longitudinal axis 5 of the holder 3, and are aligned essentially parallel to one another. It is particularly advantageous to use a circuit card as the holder 3. The specified grid size of the conductor tracks and/or contact-making points can be used with major advantage since this assists modular construction of the measurement apparatus.

The spring contacts are fitted in a particularly advantageous way to the circuit card by such spring contacts being manufactured from a wire which is bent through 90° twice. After being bent, the spring contact is approximately U-shaped, with one long end and one short end. Such a spring is illustrated, for example, in Figure 3a. The two ends are parallel to one another, and the distance between them is preferably a multiple of the circuit card grid of the contact-making unit 1. With a conventional circuit card grid size of 2.54 nm, it is advantageous for the distance between the ends to be 5.08 nm, that is to say twice the grid size.

Both ends of the spring contact are pushed into apertures in the circuit card until they reach a stop and are soldered, thus achieving high mechanical robustness against lateral movement of the spring contacts, in particular during soldering. The contacts are advantageously now parallel so that they can be pressed like a contact comb against the surface of a fuel cell stack, in which case one spring contact in each case expediently makes contact with one fuel cell in a fuel cell stack.

The arrangement either allows the voltage to be measured between a fixed reference point and voltage source units, or allows a differential voltage measurement to be carried out between respectively adjacent voltage source units. The differential voltage

measurement has the advantage that defective voltage source units can easily be located.

The contact surface between the spring contact and the fuel cell is produced by the tip of the free end of the wire, this expediently being the long end, being bent upwards with a radius of a few millimetres. This external radius of the spring wire, together with the fuel cell on the surface with which contact is to be made, represents the contact area. It is advantageous to provide a groove as a retaining surface, which groove is milled in the fuel cell surface and provides stability for the spring contact, once it has been pushed on, against undesirably being moved laterally. It is advantageous to bend the wire downwards once again, with a radius of a few millimetres, at a greater distance from the bent free end. The deflection which is produced in this way later influences the desired contact force when the contact-making unit 1 is being fitted on the fuel cell stack, avoiding subsequent, complex adjustment of the contact force. In this case, it is self-evident that the bending radius, the separation for bending, the thickness and the length of the spring contacts can be matched to the respective measurement problem.

The free end of the spring contacts can in this case not only be moved and pressed at right angles to the contact surface of the fuel cell stack, but can also be moved parallel to this contact surface, in particular parallel to the longitudinal axis 5 of the circuit card 3. This has the particular advantage that temperature-dependant thickness variations of the fuel cells during operation can reliably be compensated for, since the spring contacts can move elastically with the contact surface 7. In addition, adjustment of the spring contact with respect to the contact surfaces 7 of the fuel cells is also simplified, and the requirements for

the manufacturing tolerances of the spring contacts are less stringent. A further advantage is that it is also possible to make contact with fuel cell stacks having fuel cells of different thicknesses using the same contact-making unit, without in each case having to design and manufacture a new voltage measurement apparatus for different thicknesses in each case.

The elasticity of the spring contacts means it is also possible for more than one spring contact to make contact with a fuel cell by, for example, two adjacent spring contacts being fitted in the same contact-making groove. This makes the electrical contact particularly reliable, with a redundant design, since the second contact is functional in the event of any damage to one contact.

Figure 4 shows one advantageous arrangement. The connection means 4 are not shown. The holder 3 is arranged in a mounting such that the contact-making unit 1 can be moved along the longitudinal axis 5 which preferably runs parallel to the stacking direction of the voltage source units. It is particularly preferable for the circuit card 3 to be fixed in the vertical installation position in longitudinal guides 9 in a holder module 8. The contact-making unit 1 can be moved in the holder module 8 so that the contact-making means 2 can easily be moved over the contact surfaces 7 on the fuel cell stacks.

It is particularly advantageous for the contact-making unit 1 to have only a small number of contact-making means 2, for example 1-10 contact-making means. This advantageously makes it possible to compensate for a small amount of variance in the cell widths of the fuel cells, which can be caused, in particular, by manufacturing tolerances and/or thermal expansion. In order to allow the voltage to be tapped from a stack

with voltage source units, a number of preferably identical contact-making units 1 are used, which are plugged side by side into the longitudinal guide 9 of the holder module 8. The number of contact-making units 1 which are arranged side by side is preferably that which is necessary in order to make electrical contact with a desired number of voltage source units 6 in a stack of voltage source units. One preferred embodiment is for each individual voltage source unit 6 to be provided with a respective contact-making means 2. A further preferred embodiment is for a number of voltage source units 6 to be combined as a block, and for a contact-making means 2 to be provided for each block.

The contact-making units 1 can be moved in the longitudinal guide 9 and adjusted with respect to the voltage source units 6, and can then be fixed in the holder module 8. It is particularly advantageous to use plastic holders as the holder module 8. The use of plastic holders ensures that the arrangement has a withstand voltage such that even relatively high voltages, in particular, around 1000 V DC, can be measured with the device having adequate air gaps and creepage distances. In particular, standards which are applicable to motor vehicles can easily be complied with in terms of such requirements for withstand voltages.

The contact-making unit 1 is connected at least indirectly to an evaluation unit 10. This is shown in Figure 5. This evaluation unit 10 is preferably a central controller, which preferably has electronic data processing means and can evaluate and further process the measured voltage values which are tapped off by the contact-making means 2 of the contact-making unit 1 via the voltage source units 6. It is advantageous for the evaluation unit 10 to have a unit for addressing and/or pre-processing of measurement

data. The evaluation unit preferably has connections to a data bus, in particular a CAN bus. The modular construction of the contact-making units 1 allows measurement data to be evaluated by any desired electronic equipment.

One particularly preferred arrangement is for an intermediate unit 11 to be connected between the evaluation unit 10 and the contact-making unit 1, which intermediate unit 11 is intended at least for addressing contact-making means 2 and/or contact-making units 1 and/or for evaluating measurement data. The electrical connection between the contact-making unit 1 and the evaluation unit 10 or intermediate unit 11 is preferably produced via a ribbon cable 14 between the connection element 4 of the contact-making unit 1 and the respectively connected unit 11 or 10. The connection between the intermediate unit 11 and the evaluation unit 10 is preferably produced via a data bus. In addition, the measured voltage data recorded by the voltage measurement apparatus according to the invention can be further processed with further measurement variables, in particular analogue values such as temperature values for fuel cells, cooling water temperatures for fuel cells, gas composition, and/or information about the integrity of the data bus, information about the integrity of the electrical contact with the voltage source units 6, and other data relevant for operation of a fuel cell system, and/or fault and alarm signals, preferably using an electronic data processing system.

One advantageous method for voltage measurement in this case is to detect the voltage difference between two adjacent voltage source units.

It is particularly preferable for the intermediate unit 11 to be a microcontroller card, which is subdivided

into segments 12. It is particularly advantageous for each contact-making unit 1 to be allocated one segment 12 of the microcontroller card. In this case, it is expedient for segments 12 and contact-making units 1 to be geometrically related to a standard grid size. It is advantageous to provide at least one link to a data bus, in particular a CAN bus. The microcontroller card is preferably designed such that adequate electrical creepage distances and air gaps are provided for measuring relatively high voltages, preferably around 1000 V DC, in particular in a fuel cell vehicle.

The intermediate unit 11 is preferably arranged in a housing 13, which is preferably formed from a cover part and a bottom part. Means to accommodate the intermediate unit 11 are preferably provided in the housing 13, with the capability for the intermediate unit 11 to move within the housing 13. It is advantageous to use a standard extruded profile composed of aluminium as the housing 13, which is available as cost-effective goods sold by the metre, and whose dimensions can easily be matched to the microcontroller card. The connection points and any bushings of the housing 13 are preferably designed to be at least shower-proof, so that the microcontroller card is reliably protected against the influences of weather from all directions, particularly when the apparatus is being operated in a vehicle.

The housing 13 expediently has means for securing the contact-making units 1 and/or the holder module 8, at least mechanically on the housing 13. It is advantageous to provide the means with adjustment capabilities in order to allow the units to be moved and/or retrospectively matched to temperature-dependant length changes of the units.

In one preferred embodiment, an intermediate unit 11 is designed for a maximum number N_{max} of voltage source units 6 and/or contact-making units 1 and/or contact-making means 2 such that it is possible to measure stack versions having from 1 up to N_{max} voltage source units 6 based on the same intermediate unit 11. The microcontroller card and/or the housing 13 can be shortened to match the number of voltage source units 6 in a stack.

In one preferred embodiment, voltages from up to N_{max} = 200 fuel cells in a stack can be detected in a period in the region of a few milliseconds per channel, preferably 1 millisecond per channel. The evaluation unit 10 and any software provided for the evaluation unit are likewise expediently designed for the same maximum number N_{max}, so that the actual number of voltage measurements can be configured in a simple way by means of the software. The length of the microcontroller card is preferably at least proportional to the number of contact-making units 1 which are physically combined in the apparatus according to the invention. It is particularly preferable for the lengths of the microcontroller card, of the housing 13 and the overall length of the contact-making units 1 which are provided to be approximately the same, and, expediently, to correspond to the length of the stack of voltage source units 6. This allows the apparatus to be fitted directly, if appropriate with electrical insulation, over the voltage source units 6.

In one preferred arrangement, contact-making units 1 are at least mechanically firmly connected to the housing 13, so that contact-making units 1 and the housing 13, together with the intermediate unit 11 are arranged adjacent to the voltage source units 6, during continuous operation. The evaluation unit 10 can be

arranged remotely from this arrangement. It is also possible to arrange the housing 13 together with the intermediate unit 11 and/or the evaluation unit 10 at a relatively long distance from the voltage source units 6. It is advantageous to connect them by means of ribbon cables. The voltage source units 6 can be permanently monitored during operation.

It is particularly advantageous to provide a discharge module for individual voltage source units 6 or blocks of voltage source units 6, with the discharge module being integrated in the intermediate unit 11 or in the evaluation unit 10. The discharge module is, in particular, software-configurable and can be actuated such that, in the event of a fault, it discharges any faulty voltage source units to non-critical voltage levels, which are predetermined and/or monitored by the evaluation unit 10. Preferably, the voltage state of a cell or of a monitored cell stack is first of all measured, and it is then discharged. Any faulty voltage source units 6 can then safely be accessed by the user, for maintenance purposes.

In a further preferred arrangement contact-making units 1 are mounted such that they are at least mechanically fixed on the voltage source units 6. This is advantageous if the operating temperature of or ambient temperature around the voltage source units 6 is high. The intermediate unit 11 and the evaluation unit 10 can be accommodated remotely, in ambient temperatures which are acceptable for them. The connection to the contact-making unit 1 can then be produced as required, in particular during maintenance intervals, by the connection means 4 being electrically connected to the intermediate unit 11, or to the evaluation unit 10. The capability for decentralized installation of the modules formed by the evaluation unit 10, the intermediate unit 11 with the segments 12 in the

housing 13 and connecting cables from the connection means 4 to the contact-making unit 1, is particularly advantageous where there are space problems or problems involved in mounting on the voltage source units.

A further advantage is that, when the contact-making unit 1 is mounted directly on the stack of voltage source units 6, the voltage measurement device requires only a very small installation space. A small space requirement is particularly advantageous for installation in a vehicle with fuel cells. It is thus even possible to carry out the voltage monitoring and status monitoring of the fuel cells only at intervals during a maintenance procedure and/or during diagnosis of the vehicle, so that there is no need to install rather expensive evaluation electronics in every vehicle, and such electronics need be available only in a stationary form, in appropriate maintenance facilities. A single set of evaluation electronics at that location is then sufficient for widely differing applications. In one particularly advantageous refinement, the microcontroller card 11 is designed such that information about the number of voltage source units 6 and the nature of the interconnection of the voltage source units 6 is stored in the microcontroller. The stored information can advantageously be checked on the vehicle, from the outside, preferably by means of a plug, for carrying out a bus scan. Thus, when different versions of voltage source stacks exist, for example in different vehicle versions, the number of voltage source units 6 and the nature of the interconnection of the voltage source units 6 can be identified from the outside, without having to open the system. This is particularly maintenance-friendly.

It is thus possible to use a standard measurement system and standard software for different stack

versions of voltage source units. Based on a standard geometric design and a standard design for the addressing and/or actuation of the measurement apparatus, it is advantageously possible to provide an apparatus for a range of stacks of voltage source units 6 with different numbers of voltage source units 6 and/or with voltage source units 6 of different thicknesses.

Figure 6 shows a particularly preferred embodiment of the modular voltage measurement apparatus, as an outline diagram. A housing 13 encases a primary card as the intermediate unit 11, which has a base unit 15 which is provided with data bus connecting means on an interface card, and with elements for electronic actuation on a microcontroller card.

The size of the base unit 15 defines a minimum size L11 for the primary card 11. The base unit 15 is arranged at one end of the primary card. Multiplexer units M, each having associated connection means 4.1, are then mounted in segments 12 along the longitudinal axis of the primary card on the base unit 15. The longitudinal axis of the primary card is parallel to the stacking direction of the voltage source units 6. The connection means 4.1 are preferably pin-type plugs, which are permanently mounted on the primary card 11. Electrical cables 14 from one or more contact-making units 1 can be plugged into the pin-type plugs 4.1. The electrical cables 14 are preferably ribbon cables. Each connected contact-making means 2 may be regarded as a measurement channel. The measurement accuracy of the preferred apparatus is around ± 5 mV per channel, and the measurement rate is around 1 ms per channel.

Connection means for at least one CAN bus and one voltage supply U for the primary card are provided on the housing 13. In particular, the primary card 11 can

be operated with voltages between 7 and 36 volts. It is also possible to provide the electrical supply for the primary card by means of the voltage source units 6 with which contact has been made themselves, and the multiplex units M can advantageously be used for this purpose, so that the voltage source units 6 are not loaded asymmetrically. The contact-making means 2 are in this case addressed and switched on a cycle of milliseconds per contact-making means. Two connection options CAN1, CAN2 for CAN bus are preferably possible, so that, apart from a connection to an actuating unit 10 via a first CAN bus CAN1, it is also possible to display the measurement data visually, in particular on a portable data processing unit, which may be connected via a second CAN bus CAN2, or some other data bus.

The individual units are advantageously matched to a standard grid size in such a way that the individual modules are staggered in their extent along the longitudinal axis of the primary card. That end of the primary card 11 at which the base unit 15 is fitted is referred to as the origin. The greatest length L1 is produced by a row of contact-making units 1 which are arranged side by side, in which case L1 is of the same magnitude as the stack length L6 of the voltage source units 6. The housing 13 has a length L13 which allows a row of contact-making units 1, which are arranged side by side in the direction of their longitudinal axis 5, to be accommodated completely with the length L1. Primary card 11 has a length L11 which is shorter than L1. Segments 12 with multiplexer units M and associated connection means 4.1 are arranged at approximately equal intervals in the direction of the longitudinal axis of the primary card, with the maximum length being L12. The pin-type plugs 4.1 are arranged at approximately equal intervals on an axis with a length L4 parallel to the longitudinal axis of the primary card, with the length L4 being less than L11. The pin-

type plugs 4.1 are preferably each fitted, starting from the origin, within in each case one segment 12 above the associated multiplexer unit M, so that a pin-type plug 4.1 in each case forms the geometric termination of a segment 12. The length LM of the row of multiplexer units M is shorter than the length L4 of the row of pin-type plugs 4.1.

The minimum size L15 of the primary card 11 is governed by the extent of the base unit 15 in the longitudinal direction of the primary card. Expediently, the same number of contact-making units 1 and/or contact-making means 2 and/or voltage source units 6 correspond to each segment 12. Each length increment of the primary card 11 accordingly corresponds to an essentially constant number of contact-making units 1 and/or contact-making means 2 and/or voltage source units 6. One segment 12 is preferably arranged alongside the base unit 15, at the same level. The minimum length L15 of the primary card 11 accordingly corresponds to a minimum number of voltage source units 6 for which the apparatus according to the invention can be used. The staggering of the lengths of the individual units is shown schematically in Figure 7.

One preferred apparatus is designed for 196 voltage source units. The minimum size of the arrangement is governed by the length L15 of the base unit 15. The size of the base unit 15 corresponds to a stacking height of 70 voltage source units. Accordingly, the preferred apparatus allows contact to be made with any desired stack sizes between 70 and 196 voltage source units 6, with said apparatus being mounted directly on the voltage source stack. The individual units in the apparatus just need to be shortened to match the number of voltage source units 6 to be measured. In this case, staggering of the lengths of the individual units ensures that only a part of the primary card which is

not required is cut off whenever the primary card 11 is shortened. If the shortening is carried out between two segments 12 in each case, this ensures that no active regions of the primary card are disconnected, so that the function of the remaining units is maintained, without any disturbance. Damage to electrical supply leads and signal tracks in the part of the primary card which is fitted in the apparatus is reliably precluded by the geometric association between the segments 12 on the primary card 11 and the contact-making units 1 and/or voltage source units 6, without their being any need for costly redesign of the apparatus for different stack lengths. If there are less than 70 voltage source units 6, without there being any need for costly redesign of the apparatus for different stack lengths. If there are less than 70 voltage source units 6, the primary card 11 can either be arranged remotely from the stack, or the primary card 11 overhangs the stack, with excess contact-making units 1 and/or contact-making means 2 being unused.

The base unit 15 is designed to be very flat, with the height of the housing 13 being at most 25 mm, so that the apparatus can be fitted even in regions where little space is available. Despite the small physical height, no external cooling is required, since the cooling via the housing surface is adequate.

Figure 8 shows a side section through a preferred apparatus, illustrating details of the connection between the holding module 8 and the housing 13. The primary card 11 and the pin-type plug 4.1 are fitted inside the housing 13. A ribbon cable leads from the pin-type plug 4.1, as a flexible electrical connecting cable 14, to a contact-making unit 1. In particular, a rubber seal can be provided in the bushing region to the contact-making unit 1, in order to protect the interior of the housing from moisture and dirt. Cut-

outs are provided in the side surface of the housing 13 facing the contact-making units 1, preferably in the regions of the pin-type plugs 4.1, as a bushing for the electrical supply leads. The holding module 8 is subdivided into a lower part 8.1 and an upper part 8.2. The two parts can be detachably connected to the housing 13 by means of screws. The lower holding module part 8.1 is screwed to the housing lower part, and the contact-making unit 1 is fitted at right angles into a groove 9.1 in the part 8.1. The upper part 8.2 of the holding module 8 likewise has a groove 9.2, and the part is placed on the contact-making unit in such a way that the contact-making unit 1 can be moved within the groove. In this state, the contact-making unit 1, together with the contact-making means 2 can be adjusted with respect to the voltage source units 6. In order to fix the contact-making units 1, the upper part 8.2 is screwed onto the housing from above, so that the pressure of the part fixes the contact-making unit 1. An advantageous small height of the housing 13 is achieved if the upper housing part has a projection with appropriate screw holes for accommodating the upper part 8.2 of the holding module.

The apparatus is not just suitable for tapping off voltages, but also allows other analogue signals to be recorded or fed in, and, in particular, these can be supplied by means of the intermediate unit 11 for evaluation and/or further processing.

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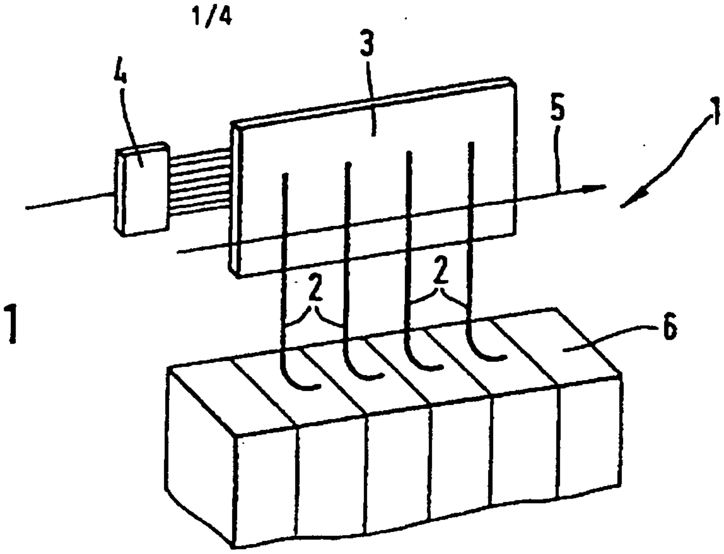

Fig. 1

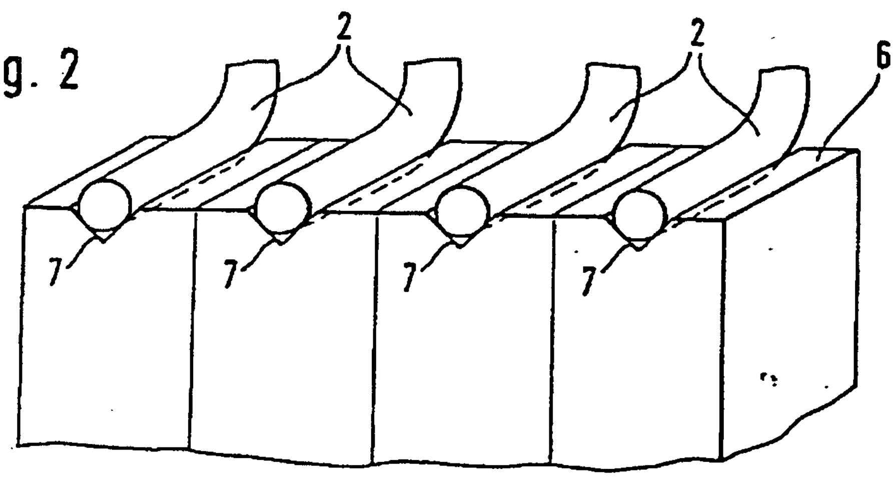

Fig. 2

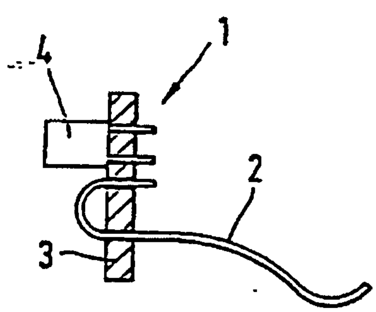

Fig. 3

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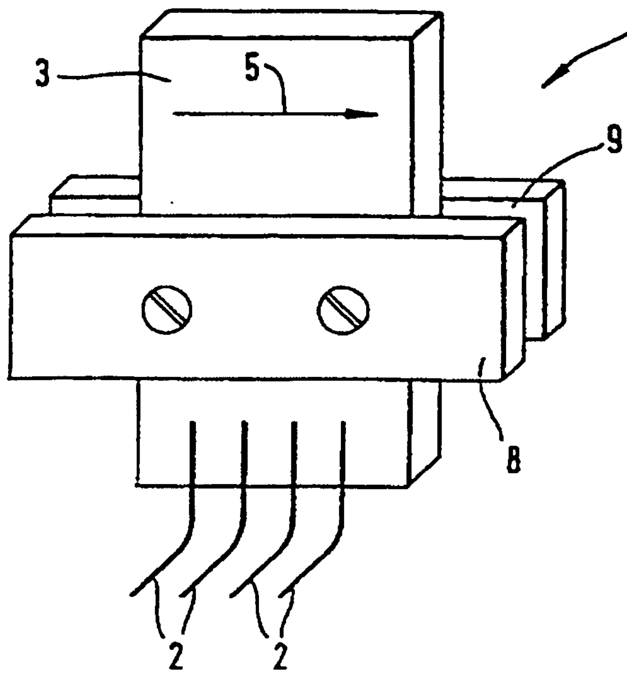

Fig. 4

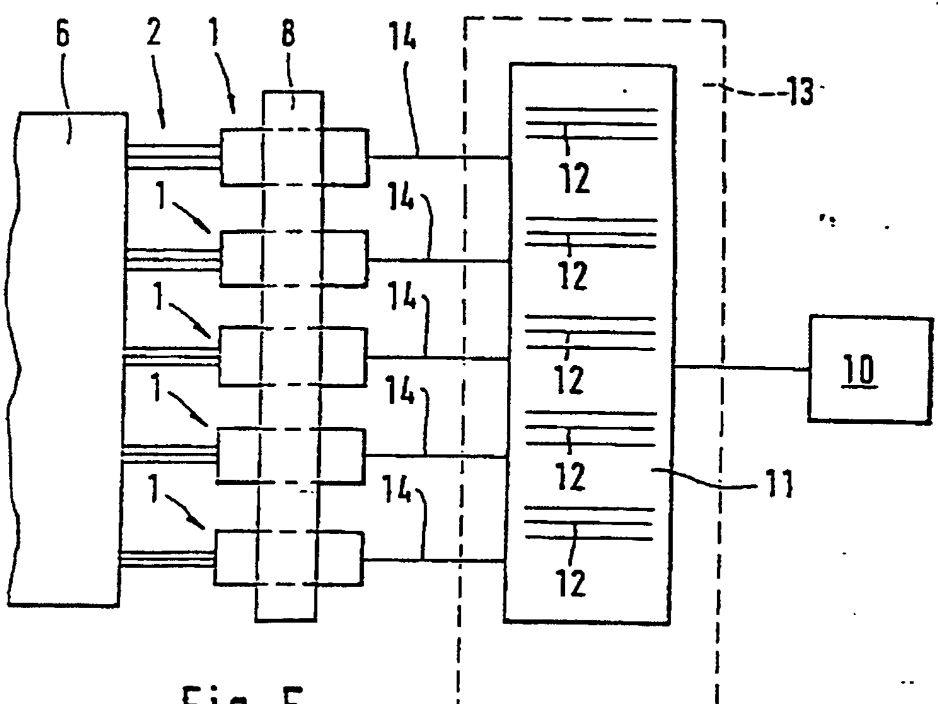

Fig. 5

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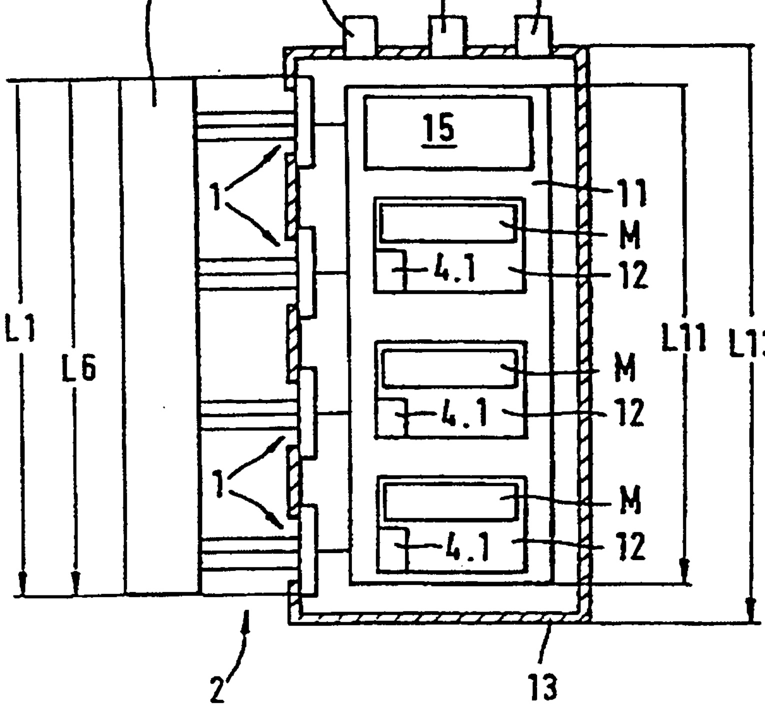

Fig. 6

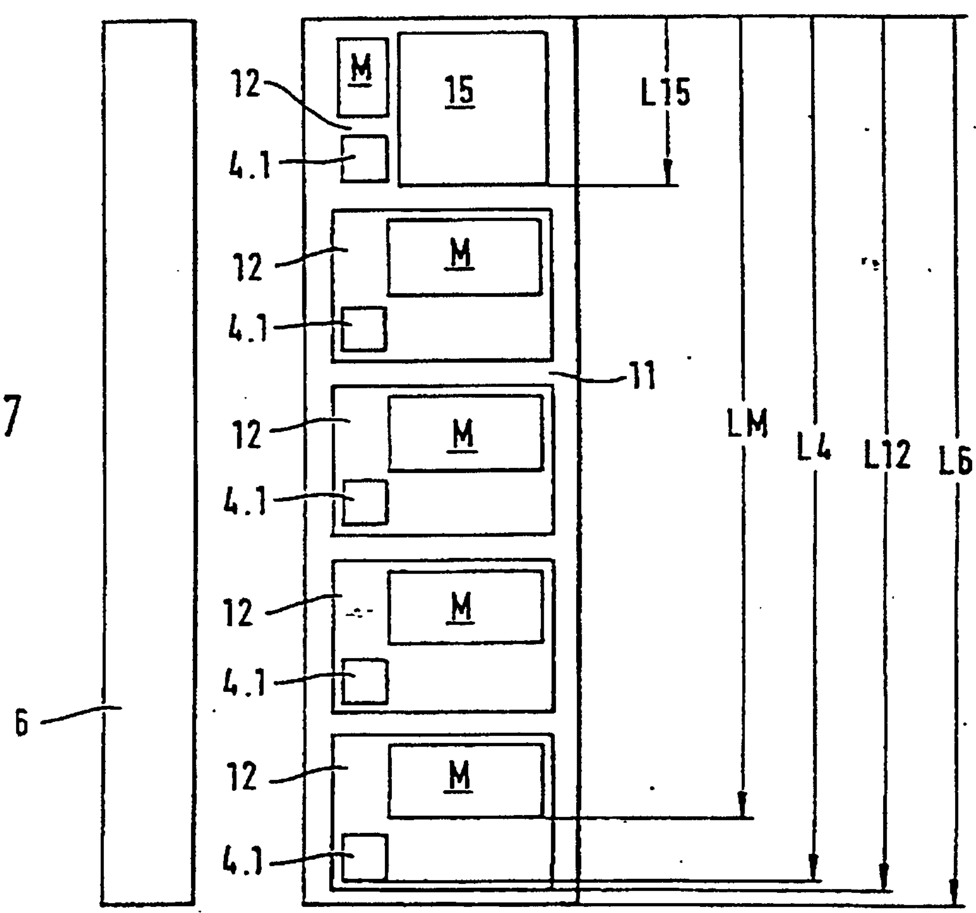

Fig. 7

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Fig. 8